

Review Article

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Influence of Ascorbic Acid Application on Quality and Storage Life of Fruits

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ABSTRACT

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India is major producer of fruits of the world with 2nd ranking. An appreciable quantity of produce is lost due to multitude of factors such as improper post-harvest operations, perishable nature; as a result, there is a huge gap between production and availability. About 10-15% fresh fruits shrivel or spoil, lowering market value along with consumer acceptability. Quality cannot be improved during storage. Selection of fruit varieties is based on marketability, yield and keeping quality because these factors affect the bottom line. Use of protective antioxidants for enhancement in shelf life of produce has been in practice and yielded appreciable results. Contributing to the list of protectants, ascorbic acid finds suitability as a preferential post harvest dip agent for shelf-life enhancement and keeping the fruit properties intact for longer durations. This article provides a comprehensive essay of the protective action of ascorbic acid treatments in fruits for enhancing the shelf-life.

Introduction

Fruit are important sources of fiber, potassium, folic acid, carbohydrates and vitamins etc. They constitute vital part of our diet. Their minor documented benefits relate to their role in preclusion of cancer and kidney functions through contribution of ascorbic acid. Vitamin C is needed for growth, development and repair of cells and tissues. It helps in making collagen in the body, leading various proteins in skin making, cartilage, ligaments, tendons and blood vessels and healing wounds. Vitamin C is an excellent antioxidant, along with beta-carotene, and many other nutrients. Researchers found that

pre-harvest prevailing conditions such as climate, light, soil type, mulching, fertilization and application of naturally occurring compounds can affect the nature of the antioxidant and antioxidant activity of various fruits (Antalovich *et al.*, 2002). Various researchers have reported Ascorbic acid as effective measure in controlling enzymatic browning of fruits and vegetables (Santerre *et al.*, 1988; Sapers *et al.*, 1989). Various kinds of molds (Fungi) in different nuts that are already roasted can be removed by application of with and ascorbic acid solution along with water (Clark, 2015). Ascorbic acid is a good antioxidant that keeps fruit from darkening and improves destruction of bacteria during

drying process. A combination of 34 grams of pure ascorbic acid into 1000 milliliters of cold water averts darkening of fruits. Application of Ascorbic acid had many stimulating effects on growth and physiological activities of various plants (Dewick, 2000, Ismail, 2008 and Abdou *et al.*, 2015). Antioxidants like ascorbic acid and citric acid have synergistic effect and auxinic action towards flowering and fruiting of fruit trees, lately, antioxidants are used instead of auxins for improving growth, development and fruiting of fruit trees (El Sayed *et al.*, 2000 and Maksoud *et al.*, 2009). Ascorbic and citric acid had ability to improve physical and chemical traits of Ruby seedless grapevine (Abdel-Salam, 2016). Antioxidants (like Ascorbic acid etc.) have auxinic and synergistic type influence on flowering and fruiting of various fruit trees. Recently some antioxidants are used instead of auxins and other substances for enhancing growth, development and fruiting of various fruit trees (El Sayed *et al.*, 2000 and Ragab, 2016). Application of Ascorbic acid results in reduction of browning in fruits and vegetables, nitrosamine formation in cured and raw meat products along with reduction of oxidation of fats and lipids and also as a dough conditioner (Takeda, 2014).

Physical changes

Fruit colour

Affirmative results regarding colour of winter crop of guava cv. Shweta fruits under ambient conditions after application of Ascorbic acid were achieved during research study. It was recorded that fruit colour changed gradually as the storage period progressed. Colour of the fruits was of green colour when harvested. Various concentration of Ascorbic acid successfully maintained the fruit colour and exhibited ultimately light yellow green colour at the end of storage (Kaur, 2016). It was discovered at Indira Gandhi Krishi

Vishwavidyalaya, Raipur that application of sulphur +citric acid in China fruits, showed minor browning with the uppermost score of fruit colour. Five varieties of litchi (viz. Sarguja Selection-1, Sarguja Selection-2, Shahi, China and Rose Scented) were treated with various chemicals during experiment and kept under ambient storage conditions (Jain, 2006). Ascorbic acid 0.1% increased the lightness (L) and decreased the redness (a) and yellowness (b) color values in peach, strawberry and apple fruit (Rababah *et al.*, 2005). The sensory features of the papaya fruits exhibited the overall advancement with application 1.5 per cent of chitosan concentration, after 5 weeks of cold storage (Ali *et al.*, 2011). It was found that Ascorbic acid has been very effective in discoloration deterioration and helpful in reduction of browning in mushroom (Hsu *et al.*, 1988). Many of researchers used 0.75% ascorbic acid to reduce browning of apple (Ponting *et al.*, 1994). Mc Evily *et al.*, (1992) discovered that Ascorbic acid is commonly used to prevent enzyme discoloration of fruits by reduction of colorless o-quinones to diphenols compound.

Fruit firmness

Treated guava fruits of cv. Allahabad Safeda with Ascorbic acid 100 ppm, stored under cold room conditions showed lowest firmness loss after 21 days of storage (Gill *et al.*, 2014). It was recorded in winter guava cv. Shweta that Ascorbic acid had influenced the fruit firmness under ambient storage conditions as compare to control (Kaur, 2016). Maximum mean fruit firmness was discovered in ber fruits treated with Ascorbic acid (Kaur, 2011). Spray of antioxidants gave exceptional result on growth and bunch characteristics of grapes cv. Thompson Seedless (Fayed, 2010). Softening of fruits might be caused either by breakdown of insoluble protopectin into soluble pectin or by hydrolysis of the starch as in banana fruit (Mattoo *et al.*, 1975).

Application of Ascorbic acids caused increase in firmness and fruit weight in mango fruit (Awad, 2006). It was reported that 1.5% CTS, alone or in combination with 10 mmol L⁻¹ ascorbic acid retained greater firmness and postponed the increase of weight loss than controls in 'Yali' pears (Lin *et al.*, 2008). Ascorbic acid proved to be effective in increasing peach fruit firmness (El-Shazly, 2013). Tomar and Kumar (1977) revealed that application ascorbic acid has resulted in increased acidity in grape var. 'Perlette' and also enhanced the bunch shape.

Palatability rating

It was proved under ambient conditions that guava fruit treated with Ascorbic acid @ 2.0 percent continued palatable up to 7th day and afterwards it declined considerably (Kaur, 2016). Treatment with ascorbic acid enhanced consumer acceptability in mango (Ahmad, 1998). Development of acids and sugars of palatability rating in guava fruits during storage might be due to the development as a consequence of hydrolysis of starch and other molecules leading to the development of flavour in fruits (Bal, 1982). The raise in organoleptic rating score under storage condition may be due to slow tempo of biochemical processes resulting from decreased transpiration and respiration rate. It was revealed in winter guava cv. 'Allahabad Safeda' that Ascorbic acid @100 ppm application retained satisfactory organoleptic rating up to 21 days in cold storage (Gill *et al.*, 2014).

Physiological loss in weight

Ascorbic acid 100 ppm treated guava fruits cv. Allahabad Safeda exhibited minimum weight loss. Treated fruits of winter guava cv. Shewta with Ascorbic acid @1.0 per cent showed less PLW than untreated (Kaur, 2016). Ascorbic acid 1000 ppm in grapes caused lower

cumulative physiological loss in weight (Ling *et al.*, 2007). Similar results are reported by in pear (Ling *et al.*, 2007) and ber (Siddiqui *et al.*, 1995). Maximum fruit spoilage was accessed in control followed by Ascorbic acid treatment. Foliar application of ascorbic acid has positive effect on weight and dimensions of the berry (ber) fruit (Kaur, 2016). These results are supported by various researchers (Maximos *et al.*, 1995 and Wassel, 1985). Ascorbic acid might reduce the production of ethylene and respiration processes by hindering the probable free radical intervening ACC to pathway of ethylene (Apelbaum *et al.*, 1981a). Experimentation with "Anna" apple revealed that physical and chemical characteristics were enhanced by spraying citric acid at 0.1% at start of growth, just after fruit set and at 21 days later (Ahmed and Abd, 2007). It was proved in "Swelling" peach trees that foliar application of ascorbic acid lead to an increase in fruit weight (Gill *et al.*, 2014). Weight loss of 5 per cent under storage conditions, is the highest permissible limit in case of fruits, above which the fruits exhibit shriveling and becomes unmarketable (Mahajan *et al.*, 2009). PLW increased during the storage period regardless of Ascorbic acid treatment. While working in winter guava cv. 'Allahabad Safeda' it was reported that Ascorbic acid treated fruits registered the minimum mean PLW. It was observed that the average PLW decreased appreciably by boosting the concentration of Ascorbic acid (Gill *et al.*, 2014). It was established in ber fruits that treatment with Ascorbic acid @ 100 ppm at low temperature storage declined the physiological loss (Banik *et al.*, 1988). Application of Ascorbic acid @ 2 per cent caused least physiological weight loss in ber fruits (Kaur, 2014). Minimum physiological weight loss was noted after 7 days and maximum after 28 days of storage. The PLW was drastically increased with prolongation of storage. Ascorbic acid seems to be an effective antioxidant for improving yield, fruit weight

content of olive trees (Maksoud *et al.*, 2009). Sun *et al.*, (2010) recorded higher TSS, acidity and lower weight loss and decay rate in litchi fruits treated after harvest with Ascorbic acid. Ozdemir and Gökmen (2017) proved that chitosan-ascorbic acid coating has no effect on physiological weight loss whereas the control treatment, 1% ascorbic acid and coated fruits lost alike weight during storage of 28 days. Puthmee *et al.*, (2010) recorded that applications of ascorbic acid were very effective in reducing fruit weight loss, microbial growth and color changes.

Fruit spoilage

It was revealed that Ascorbic acid treatments significantly decreased the post-harvest losses and extended shelf-life of the guava fruits (Jayachandran *et al.*, 2007). Ascorbic acid protected various fruits against harmful effects of oxidative processes and biotic stresses due to improved levels of antioxidants that might prevent much softening and rotting of fruits (Paliyath *et al.*, 2008). Application of Ascorbic acid @100 ppm showed least decay incidence score in guava. However, low concentration of Ascorbic acid was found at par; yet significantly in minimize decay incidence (Gill *et al.*, 2014). Least spoilage was reported in ber fruits when Ascorbic acid was applied (Banik *et al.*, 1988 and Siddiqui and Gupta, 1989). Fruit spoilage was less in ber fruit in Ascorbic acid 2 per cent treatment when kept in cold storage (Kaur, 2014).

Bio-chemical changes

Total soluble solids

Application of Ascorbic acid 100 ppm in winter guava cv. 'Allahabad Safeda' exhibited higher TSS (Gill *et al.*, 2014). Treatment with Ascorbic acid @ 150 and 300 ppm enhanced TSS (Siddiqui, S. and Gupta, 1989). It was reported in mango fruits cv. Alphonso and

"Badami" that spraying with Ascorbic and citric acids at 200, 300 and 400 ppm, improved many bio chemical characters like total soluble solids, ascorbic acid and total sugars (Awad, 2006). Spraying with ascorbic acid along with GA₃ improved "Canino" apricot quality. GA₃ at 25 and 50 ppm along with ascorbic acid at 50 ppm had no significant influence towards TSS (%) of plum fruits (Nabil *et al.*, 2013). TSS of guava fruits was at its lowest with Ascorbic acid 1000 ppm stored under ambient conditions (Rajput *et al.*, 2015). When ber fruits were applied with Ascorbic acid, exhibited an enhancement in TSS but followed a decreasing trend at later period of storage (Kaur, 2011). Strawberry (Camarosa and Red Dream varieties) and Raspberry (Killarney and Nova varieties) fruits were harvested in Georgia and treated with 0%, 1% or 2% solution of Ascorbic acid at 20 ± 1 °C temperature and stored at -40 °C. It was accomplished that after 3 months of storage period that TSS of raspberry and strawberry fruits were declined by 10–14% in treated and controlled samples (Turmanidze *et al.*, 2017).

Acidity

Under normal conditions that Ascorbic acid @2.0 per cent exhibited advanced level of acidity in winter crop of guava cv. Shweta. Minimum acid content was observed in untreated fruits. A decline in acidity and amplification in pH of fruit was recorded during the storage period in lemon (Pesis *et al.*, 1999). Liu *et al.*, (2006) submitted that isoascorbic acid had a good effect in sustaining quality of litchi fruit quality in terms of TSS, titratable acidity and ascorbic acid of the pulp.

Reduction in acid content of guava fruits with the enhancement in storage duration might be endorsed to the use of organic acids in respiration process by the cells and change of

acids into total sugars (Echeverria and Valich, 1989). Guava fruits treated with Ascorbic acid retained advanced acidity during the storage, probably due to postponed ripening process. Similar values also have been established in guava by different research workers (Jayachandran *et al.*, 2005). Acid content in guava followed a declining fashion during cold storage. Decline in the acid content of the fruit was more rapid in the untreated guava fruits whereas treated fruits were recorded a regular descending acidity level (Gill *et al.*, 2014). Post-harvest dipping in Ascorbic acid solution @ 150 and 300 ppm had no effect towards acidity (Siddiqui and Gupta, 1989). It was revealed in ber that the acid content of fruits stored under room temperature ($25\pm 5^{\circ}\text{C}$) was not affected by Ascorbic acid (300 ppm) treatment (Siddiqui and Gupta, 1995). When fruits of *Ziziphus jujuba* cv. Linyilizao were dipped in different concentrations of citric acid (0.5, 1.0 and 1.5%) for 3 hours and stored under refrigerator (4°C) conditions revealed that citric acid treatment @ 0.5 percent was more effectual towards titratable acidity (Hossain *et al.*, 2014). Kumar *et al.*, (2009) reported higher TSS, titratable acidity and ascorbic acid in fruits of litchi treated with 1.0% iso ascorbic acid after 6 days of harvest process.

Vitamin C

A declining trend was recorded after treatment with Ascorbic acid (0.2% and 0.3%) low temperature (4°C) in guava (Hossain *et al.*, 2014). Decrease in Ascorbic acid during storage could be due to alteration of Ascorbic acid to dehydroAscorbic acid or due to action of Ascorbic acid oxidase (Mapson, 1970). When fruits of winter guava cv. 'Allahabad Safeda' treated with Ascorbic acid 100 ppm revealed maximum Vitamin C content (Gill *et al.*, 2014). Maximum vitamin C content was observed in guava fruits with treatment of Ascorbic acid @2.0 percent

under cold storage (Kaur, 2016). It was observed that post-harvest treatment in Ascorbic acid @ 150 and 300 ppm had no effect on Ascorbic acid in storage (Siddiqui and Gupta, 1989). It was accessed that when ber fruits were treated with Ascorbic acid, exhibited an enhancement in total sugars up to 14 days of storage but trailed a decrease in later phase of storage. Higher retention of vitamin C was observed in fruits of ber with Ascorbic acid application (Kaur, 2011).

It was revealed that maximum vitamin C content in guava cv. Shweta fruits caused with application of Ascorbic acid @ 2.0 per cent under ambient conditions (Kaur, 2016). Citric acid applications had no adverse effect on Ascorbic acid of ber in cv. Gola, with progression of the storage period (Banik *et al.*, 1988). It was proved that treatment with Ascorbic acid @300 ppm in ber cv. Umran, had no effect towards Vitamin C (Siddiqui and Gupta, 1995). Various citric acid treatments resulted in the highest level of the Ascorbic acid in *Ziziphus jujuba* fruits. Excellent results by application of citric acid @ 1.5% (Zhao *et al.*, 2009). Treatment of ascorbic acid resulted in improved yield and fruit quality of the olive trees (Makaoud *et al.*, 2009). Kumar *et al.*, (2013) reported higher TSS, titratable acidity and ascorbic acid in litchi fruits treated with iso ascorbic acid after harvest. Spanou and Giannouli, (2013) discovered that the combination of carboxyl methyl cellulose and sodium alginate with ascorbic acid or with green tea can be used as a potential moisture barrier, causing resulting increase potato samples self-life. They suggested that both green tea and ascorbic acid are potential inhibitors of dehydration and natural antioxidants.

Total sugars

Total sugars were increased during storage in ber. This increase was might be due to the

dehydration, as the fruits in most of the applications including Ascorbic acid @ 1 per cent (Jawanda *et al.*,1980b). Minimum total sugar was recorded in ber when treated with Ascorbic acid @100 ppm. Highest total sugars were observed in ber fruits when treated with Ascorbic acid 3 per cent (Banik *et al.*,1988). Maximum total sugars were noted in fruits with Ascorbic acid 2 per cent followed by Ascorbic acid 3 per cent after 7th days of storage. After 14 days of ambient storage, highest total sugars were observed in *Zizyphus jujube* (Zhao *et al.*, 2009). Spraying of ascorbic acid in "Kelsey" plum trees, improved fruit quality as compared with the controlled trees (Mohamed, 2008). Spraying of ascorbic acid on "Le- Conte" pear fruits that improved total and non-reducing sugars (Hafez *et al.*, 2010). When ber fruits were dipped in Ascorbic acid, displayed an increase in total sugars up to 14 days of storage but followed a decline trend at later period of storage (Kaur,2011). It was explained in olive trees that application of ascorbic acid 2000 ppm enhanced yield and fruit quality. Where, reduction in concentration up to 1000 ppm had worthless effect (Maksoud *et al.*, 2009). An increase in sugar content of tomato crop was reported by foliar application of ascorbic acid (Biacs *et al.*,1988). Increase in TSS as a result of ascorbic acids sprays may be due to its influence in increasing photosynthetic pigment which revealed on photosynthesis process and led to enhance in carbohydrate content (Fayed, 2010). Nehra *et al.*, (1987) recorded significant increase in seed yield per plant and the effect was found to be reliant on the used quantities of ascorbic acid.

In conclusion, different concentration of Ascorbic acid was helpful in retaining fruit colour and exhibited ultimately light yellow green colour at the end of storage. Its application maintained significantly higher firmness, enhancement in consumer acceptability and reduction of post-harvest

losses along with lowering of cumulative physiological loss in weight along with satisfactory organoleptic rating. But it has no significant effect on spoilage of fruits. Ascorbic acid @2.0 per cent exhibited advanced level of acidity and revealed maximum vitamin C content. Highest total sugars were recorded in its treatment. Ascorbic acid @100 ppm displayed higher TSS under cold storage.

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